CLAIMS

1. A method of forming a metallic article, comprising:

providing an ingot of metallic material; the ingot having an initial grain size greater than 250 microns, and an initial thickness;

subjecting the ingot to hot forging at a temperature of from about 700°F to about 1100°F under sufficient pressure and time to reduce a thickness of the ingot to from about 10% to about 60% of the initial thickness; the hot forging converting the ingot into a hot-forged product;

quenching the hot-forged product to fix an average grain size less than 250 microns within the metallic material; the quenched material being a metallic article;

wherein the hot forging is conducted in a press;

wherein the hot-forged product is removed from the press after the hot forging; and

wherein the quenching comprises reducing a temperature of an entirety of the hot-forged product to less than or equal to about 150°F within about 15 minutes of removing the hot-forged product from the press.

2. The method of claim 1 wherein the metallic material comprises copper having a purity of at least 99.995 weight percent.

3. The method of claim 1 wherein the metallic material comprises one or more of Ni, Co, Ta, Al, and Ti.

4. The method of claim 1 wherein the metallic material comprises copper together with one or more of Cd, Ca, Au, Ag, Be, Li, Mg, Al, Pd, Hg, Ni, In, Zn, B, Ga, Mn, Sn, Ge, W, Cr, O, Sb, Ir, P, As, Co, Te, Fe, S, Ti, Zr, Sc, and Hf.

5. The method of claim 1 wherein the metallic material consists essentially of copper and at least one element selected from the group consisting of Cd, Ca, Au, Ag, Be, Li, Mg, Al, Pd, Hg, Ni, In, Zn, B, Ga, Mn, Sn, Ge, W, Cr, O, Sb, Ir, P, As, Co, Te, Fe, S, Ti, Zr, Sc, Sn and Hf; and wherein the copper is present to a concentration of less than or equal to about 99.99%, by weight.

6. The method of claim 5 wherein the at least one element is selected from the group consisting of Ag, Al, In, Zn, B, Ga, Mn, Sn, Ge, Ti and Zr.

7. The method of claim 5 wherein a total amount of the at least one element is from at least about 100 ppm to less than about 10%, by weight.

8. The method of claim 5 wherein a total amount of the at least one element is from at least 1000 ppm to less than about 2%, by weight.

9. The method of claim 1 wherein the metallic material consists essentially of CuSn, with the Sn being present to from about 100 ppm, by weight, to about 3 atomic percent.

10. The method of claim 1 wherein the metallic material consists essentially of CuAl, with the Al being present to from about 100 ppm, by weight, to about 3 atomic percent.

11. The method of claim 1 wherein the metallic material consists essentially of CuAg, with the Ag being present to from about 100 ppm, by weight, to about 3 atomic percent.

12. The method of claim 1 wherein the fixed average grain size is less than 200 microns.

13. The method of claim 1 wherein the fixed average grain size is less than 100 microns.

14. The method of claim 1 further comprising forming the metallic article into a physical vapor deposition target.

15. The method of claim 1 further comprising forming the metallic article into a three-dimensional physical vapor deposition target, the forming metallic article into a three-dimensional physical vapor deposition target comprising:

providing the press to have a first portion receivable within a second portion;

positioning the metallic article between the first and second portions of the press; and

pressing the metallic article between the first and second portions to shape the metallic article into about the shape of the three-dimensional physical vapor deposition target.

16. A method of forming a cast ingot, comprising:

providing a mold having an interior cavity;

partially filling the interior cavity with a first charge of molten metallic material to leave a remaining unfilled portion of the interior cavity;

cooling the first charge of molten material within the interior cavity to partially solidify the first charge of molten material; the first charge being agitated within the interior cavity during at least some of the cooling;

while the first charge of molten material is only partially solidified, at least partially filling the remaining unfilled portion of the cavity with a second charge of the molten material; and

cooling the first and second charges of the molten material within the interior cavity to form an ingot comprising the first and second charges of material; the second charge being agitated within the interior cavity during at least some of the cooling of the second charge.

17. The method of claim 16 wherein the ingot has a cylindrical shape comprising a thickness and a diameter; and wherein any shrinkage cavity formed in a top of the ingot during the casting process has a depth less than 10% of the thickness of the cylindrically-shaped ingot.

18. The method of claim 16 wherein the ingot has a cylindrical shape comprising a thickness and a diameter; and wherein any shrinkage cavity formed in a top of the ingot during the casting process has a depth less than 2% of the thickness of the cylindrically-shaped ingot.

19. The method of claim 16 wherein the molten material consists essentially of a metallic material.

20. The method of claim 16 wherein the molten material comprises copper having a purity of at least about 99.995 weight percent.

21. The method of claim 16 wherein the first charge fills from about 50% to about 90% of a volume of the interior cavity.

22. The method of claim 16 wherein the first charge fills from about 5% to about 50% of a volume of the interior cavity.

23. The method of claim 16 wherein the first charge fills about 50% of a volume of the interior cavity; wherein the second charge fills less than or equal to about 10% of the volume of the interior cavity; and further comprising providing additional charges of the molten material within the interior cavity subsequent to the provision of the second charge, each charge being placed within the cavity after only partial solidification of at least some of the material provided in the cavity from preceding charges.

24. A physical vapor deposition target comprising:

a shape, the shape including at least one cup having a first end and a second end in opposing relation to the first end; the first end having an opening extending therein; the cup having a hollow therein; the hollow extending from the opening in the first end toward the second end; the cup having an interior surface defining a periphery of the hollow; the shape including an exterior surface extending around an exterior of the cup and in opposing relation to the interior surface; the exterior surface comprising a region which wraps around at least a portion of the second end with a rounded corner; the rounded corner having a radius of curvature of at least about 1 inch; and

a sputtering surface defined along the interior surface of the cup.

25. The physical vapor deposition target of claim 24 wherein the interior surface does not comprise a rounded corner having a radius of curvature of at least about 1 inch.

26. The physical vapor deposition target of claim 24 wherein the interior surface comprises a rounded corner having a radius of curvature of at least about 1 inch.

27. The physical vapor deposition target of claim 24 wherein the interior surface comprises a rounded corner having a radius of curvature of at least about 1 inch; and wherein the rounded corner of the interior surface is within the rounded corner of the exterior surface.

28. The physical vapor deposition target of claim 24 consisting essentially of high purity copper.

29. The physical vapor deposition target of claim 24 consisting essentially of Ta.

30. The physical vapor deposition target of claim 24 consisting essentially of Ti.

31. The physical vapor deposition target of claim 24 comprising one or more of Cu, Ni, Co, Ta, Al, and Ti.

32. The physical vapor deposition target of claim 24 comprising copper together with one or more of Cd, Ca, Au, Ag, Be, Li, Mg, Al, Pd, Hg, Ni, In, Zn, B, Ga, Mn, Sn, Ge, W, Cr, O, Sb, Ir, P, As, Co, Te, Fe, S, Ti, Zr, Sc, and Hf.

33. The physical vapor deposition target of claim 24 consisting essentially of copper and at least one element selected from the group consisting of Cd, Ca, Au, Ag, Be, Li, Mg, Al, Pd, Hg, Ni, In, Zn, B, Ga, Mn, Sn, Ge, W, Cr, O, Sb, Ir, P, As, Co, Te, Fe, S, Ti, Zr, Sc, Sn and Hf; and wherein the copper is present to a concentration of less than or equal to about 99.99%, by weight.

34. The physical vapor deposition target of claim 33 wherein the at least one element is selected from the group consisting of Ag, Al, In, Zn, B, Ga, Mn, Sn, Ge, Ti and Zr.

35. The physical vapor deposition target of claim 33 wherein a total amount of the at least one element is from at least about 100 ppm to less than about 10%, by weight.

36. The physical vapor deposition target of claim 33 wherein a total amount of the at least one element is from at least 1000 ppm to less than about 2%, by weight.

37. The physical vapor deposition target of claim 24 consisting essentially of CuSn, with the Sn being present to from about 100 ppm, by weight, to about 3 atomic percent.

38. The physical vapor deposition target of claim 24 consisting essentially of CuAl, with the Al being present to from about 100 ppm, by weight, to about 3 atomic percent.

39. The physical vapor deposition target of claim 24 consisting essentially of CuAg, with the Ag being present to from about 100 ppm, by weight, to about 3 atomic percent.

40. The physical vapor deposition target of claim 24 wherein the exterior surface wraps entirely around the second end.

41. The physical vapor deposition target of claim 24 wherein the radius of curvature is at least about 1.5 inches.

42. The physical vapor deposition target of claim 24 wherein the radius of curvature is at least about 1.7 inches.

43. The physical vapor deposition target of claim 24 wherein the radius of curvature is at least about 1.8 inches.

44. The physical vapor deposition target of claim 24 wherein the shape consists essentially of a material having an average grain size of less than or equal to 250 microns.

45. The physical vapor deposition target of claim 24 wherein the shape consists essentially of a material having an average grain size of less than or equal to 200 microns.

46. The physical vapor deposition target of claim 24 wherein the shape consists essentially of a material having an average grain size of less than or equal to 100 microns.

47. The physical vapor deposition target of claim 24 wherein the shape consists of a material having an average grain size of less than or equal to 250 microns.

48. The physical vapor deposition target of claim 24 wherein the shape consists of a material having an average grain size of less than or equal to 200 microns.

49. The physical vapor deposition target of claim 24 wherein the shape consists of a material having an average grain size of less than or equal to 100 microns.

50. A magnetron plasma sputter reactor comprising:

a plasma chamber configured to accommodate a substrate to be sputter coated;

the physical vapor deposition target of claim 24 within the chamber; and

a configuration of magnetic materials proximate the target and configured to generate a magnetic field having magnetic field lines extending within the hollow of the target.

51. The magnetron plasma sputter reactor of claim 50 wherein the target interior surface does not comprise a rounded corner having a radius of curvature of at least about 1 inch.

52. The magnetron plasma sputter reactor of claim 50 wherein the target interior surface comprises a rounded corner having a radius of curvature of at least about 1 inch.

53. The magnetron plasma sputter reactor of claim 50 wherein the target interior surface comprises a rounded corner having a radius of curvature of at least about 1 inch; and wherein the rounded corner of the interior surface is within the rounded corner of the exterior surface.

54. The magnetron plasma sputter reactor of claim 50 wherein the target consists essentially of high purity copper.

55. The magnetron plasma sputter reactor of claim 50 wherein the target consists essentially of Ta.

56. The magnetron plasma sputter reactor of claim 50 wherein the target consists essentially of Ti.

57. The magnetron plasma sputter reactor of claim 50 wherein the target comprises one or more of Cu, Ni, Co, Ta, Al, and Ti.

58. The magnetron plasma sputter reactor of claim 50 wherein the target material consists essentially of CuSn, with the Sn being present to from about 100 ppm, by weight, to about 3 atomic percent.

59. The magnetron plasma sputter reactor of claim 50 wherein the target material consists essentially of CuAl, with the Al being present to from about 100 ppm, by weight, to about 3 atomic percent.

60. The magnetron plasma sputter reactor of claim 50 wherein the target material consists essentially of CuAg, with the Ag being present to from about 100 ppm, by weight, to about 3 atomic percent.

61. The magnetron plasma sputter reactor of claim 50 wherein the target exterior surface wraps entirely around the second end.

62. The magnetron plasma sputter reactor of claim 50 wherein the radius of curvature is at least about 1.5 inches.

63. The magnetron plasma sputter reactor of claim 50 wherein the radius of curvature is at least about 1.7 inches.

64. The magnetron plasma sputter reactor of claim 50 wherein the target shape consists essentially of a material having an average grain size of less than or equal to 250 microns.

65. The magnetron plasma sputter reactor of claim 50 wherein the target shape consists essentially of a material having an average grain size of less than or equal to 200 microns.

66. The magnetron plasma sputter reactor of claim 50 wherein the target shape consists essentially of a material having an average grain size of less than or equal to 100 microns.

67. A three-dimensional physical vapor deposition target, comprising:

a material comprising one or more of Cu, Ni, Co, Ta, Al, and Ti;

an average grain size of less than or equal to 250 microns within the material;

a shape, the shape including at least one cup having a first end and a second end in opposing relation to the first end; the first end having an opening extending therein; the cup having a hollow therein; the hollow extending from the opening in the first end toward the second end; the cup having an interior surface defining a periphery of the hollow; and

a sputtering surface defined along the interior surface of the cup.

68. The three-dimensional physical vapor deposition target of claim 67 wherein the material consists essentially of copper; and wherein the target consists essentially of the material.

69. The three-dimensional physical vapor deposition target of claim 67 wherein the material consists essentially of tantalum; and wherein the target consists essentially of the material.

70. The three-dimensional physical vapor deposition target of claim 67 wherein the material consists essentially of CuSn, with the Sn being present to from about 100 ppm, by weight, to about 3 atomic percent; and wherein the target consists essentially of the material.

71. The three-dimensional physical vapor deposition target of claim 67 wherein the material consists essentially of CuAl, with the Al being present to from about 100 ppm, by weight, to about 3 atomic percent; and wherein the target consists essentially of the material.

72. The three-dimensional physical vapor deposition target of claim 67 wherein the material consists essentially of CuAg, with the Ag being present to from about 100 ppm, by weight, to about 3 atomic percent; and wherein the target consists essentially of the material.

73. The three-dimensional physical vapor deposition target of claim 67 wherein the average grain size is less than or equal to 200 microns.

74. The three-dimensional physical vapor deposition target of claim 67 wherein the average grain size is less than or equal to 100 microns.

75. The three-dimensional physical vapor deposition target of claim 67 wherein the average grain size is less than or equal to 90 microns.

76. The three-dimensional vapor deposition target of claim 67 wherein the average grain size is less than or equal to 85 microns.

77. The three-dimensional physical vapor deposition target of claim 67 being in a shape of an Applied Materials Self Ionized Plasma Plus™ target.

78. The three-dimensional physical vapor deposition target of claim 67 being in a shape of a Novellus Hollow Cathode Magnetron™ target.

79. A magnetron plasma sputter reactor comprising:

a plasma chamber configured to accommodate a substrate to be sputter coated;

the three-dimensional physical vapor deposition target of claim 67 within the chamber; and

a configuration of magnetic materials proximate the target and configured to generate a magnetic field having magnetic field lines extending within the hollow of the target.

80. The magnetron plasma sputter reactor of claim 79 wherein the target material consists essentially of copper.

81. The magnetron plasma sputter reactor of claim 79 wherein the target material consists essentially of tantalum.

82. The magnetron plasma sputter reactor of claim 79 wherein the target material consists essentially of CuSn, with the Sn being present to from about 100 ppm, by weight, to about 3 atomic percent.

83. The magnetron plasma sputter reactor of claim 79 wherein the target material consists essentially of CuAl, with the Al being present to from about 100 ppm, by weight, to about 3 atomic percent.

84. The magnetron plasma sputter reactor of claim 79 wherein the target material consists essentially of CuAg, with the Ag being present to from about 100 ppm, by weight, to about 3 atomic percent.

85. The magnetron plasma sputter reactor of claim 79 wherein the target material average grain size is less than or equal to 200 microns.

86. The magnetron plasma sputter reactor of claim 79 wherein the target material average grain size is less than or equal to 100 microns.

87. The magnetron plasma sputter reactor of claim 79 wherein the target material average grain size is less than or equal to 90 microns.

88. The magnetron plasma sputter reactor of claim 79 wherein the target material average grain size is less than or equal to 85 microns.

89. The magnetron plasma sputter reactor of claim 79 wherein the target shape is that of an Applied Materials Self Ionized Plasma Plus™ target.